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THE CREATURES WE BREATHE.

That the air we breathe is more or less laden with living organisms is a fact which is far from acceptable to most persons, and yet it would require but little persuasion to convince the majority of mankind that air without organisms would be undesirable indeed; for without one micro-organism at least, which is very widely distributed in the air, we should have to forego those numerous, complex, and much appreciated pleasures which are derived from the consumption of alcohol in its various forms. How many would vote the earth flat and stale but for the products which are alone elaborated by *yeast*, which was the first micro-organism to receive attention, and which, in spite of the many powerfully organised endeavours to undermine its position, is likely also to be the last to absorb the interest of man.

But there are other micro-organisms in the air besides yeast, and it is the firm conviction that many zymotic diseases are propagated by means of air-carried microbes, that renders the investigation of the subject of aërial micro-organisms peculiarly interesting and attractive.

The systematic examination of the aërial microbia commences with those marvellous discoveries with which the name of Pasteur is so inseparably connected, and with which the latter half of the nineteenth century will for ever be associated.

These now classical researches of Pasteur's on the presence of micro-organisms in the atmosphere were undertaken in connection with the fierce controversy which raged thirty years ago on the *Spontaneous Generation of Life.*

The supporters of this doctrine contended that the presence of the smallest particle of *air* was sufficient to determine the generation of low forms of life in certain highly putrescible substances, such as milk, blood, broth, and the like. But the opposition to this theory, marshalled by M. Pasteur, contended that it was not the air, but *certain living germs suspended in the air*, which, gaining access to tecture. All that can be done is, if possible, to arrest the attention of a larger number of persons every year, to enlist a wider sympathy, and to give increased publicity to the destruction of ancient monuments, and also to their abstraction whenever such occur. Sometimes fruit is borne. The owner of Coningsborough Castle is at last taking steps for its preservation, and perhaps some day Kirkstall Abbey may meet with similar protection. The two most hideous spectacles Mr. Ruskin ever saw were in the West Riding of Yorkshire (in both cases scenery to be felt in the pocket), and there remains but little over which a guard can be set. Yet our ruined castles and abbeys play an important part in English holidays, even if their traditions and architecture are not thought worthy of interest, while our sepulchral monuments can boast that they inspired the following passage, with which this paper may fitly end:—

> When I look upon the tombs of the great, every emotion dies in me; when I read the epitaphs of the beautiful, every inordinate desire goes out; when I meet with the grief of parents upon a tombstone, my heart melts with compassion; when I see the tomb of the parents themselves, I consider the vanity of grieving for those whom we must quickly follow; when I see kings lying by those who deposed them, when I consider rival wits placed side by side, or the holy men who divided the world with their contests and disputes, I reflect with sorrow and astonishment on the little competitions, factions, and debates of mankind. When I read the several dates of the tombs, of some that died yesterday, and some six hundred years ago, I consider that great day when we shall all of us be contemporaries and make our appearance together.

CHARLES MILNES GASKELL.

these putrescible materials, give rise to those growths which make their appearance in them.

That Pasteur succeeded in proving the truth of this assumption is now well known, and it was in connection with the elaborate and beautifully planned investigation which he conducted, to place it beyond all reach of doubt, that we have handed down to us the first systematic series of experiments made on the presence of micro-organisms in the atmosphere.

Pasteur exposed specially prepared flasks containing some highly nourishing fluid, such as clear broth, in various places, with the following striking results.

Of twenty exposed in the open country of Arbois, eight became subsequently turbid, or, in other words, eight had become contaminated with micro-organisms. Of twenty exposed on the lower heights of the Jura mountains, five became affected, whilst out of twenty others exposed at the Montanvert, close to the Mer de Glace, at a height of upwards of six thousand feet, only one flask broke down.

Thus it appears that the higher the altitude reached, and the greater the distance from human habitations, the purer, as regards the presence of micro-organisms, is the atmosphere. These are facts which subsequent experiments by other methods have fully borne out.

The beautiful experiments which Professor Tyndall carried out in this country on the presence of micro-organisms in air are well known to all, and it is to him we owe the important discovery of the rapid subsidence of these microbes in calm air. Miquel again has shown how dependent is the distribution of these microbes in air upon their surroundings, by the experiments made at Montsouris at different seasons of the year ; but the following results obtained in London, and by a more recent and more accurate method, show very clearly that the maximum number are to be found in the hottest months of the year.

Thus, in a volume of air equal to about two gallons (ten litres) collected on the top of the Science and Art Department buildings at South Kensington, at a height, therefore, of some seventy feet from the ground, and so removed from any *local* disturbance of the air, I found the following numbers of micro-organisms in the several months of the past year :—

January, 4.
March, 26.
May, 31.
June, 54.
July, 63.
August, 105.
September, 43.
October, 35.
November, 13.
December, 20.

In the country, as might have been anticipated, I have found a very appreciably smaller number of micro-organisms than in air in London. Moreover, the more remote the place is from houses and from the frequented thoroughfares of traffic, the dust of which is always rich in refuse organic matter, the freer does the air become from suspended microbes. Thus the air of an extensive heath near Norwich was found to contain from five to seven micro-organisms in the two gallons of air, whilst in that of a *garden* near Norwich were found as many as thirty-one. Again, on the Chalk Downs in Surrey I found on one occasion only two; this, however, was very early in the year (February 1886), and snow was on the ground; later on, at the end of May in the same year, I found thirteen, but in a garden near Reigate on the same day there were twenty-five. So that there is a considerable difference found in the microbial richness of the air in different places in the country. I have also tested the London air under the most favourable conditions, viz.: in the open spaces in the parks, and these experiments show that although such air generally contains fewer microbes than the air even on the roof of the Science Schools (at a height of seventy feet), yet the number is in excess of that found in the country, although the situations chosen were large surfaces of grass from which little or no dust could be blown about. But the air in the streets was found to contain numbers immensely in excess of anything that was discovered in the country, the result being in some instances as high as 554 in the two gallons of air. This last figure was obtained in the Exhibition Road on a dry and dusty day when vast multitudes of people were thronging to the Colonial and Indian Exhibition which was then open.

The striking contrast to the number of micro-organisms found in the various places previously referred to is the number found in the air at sea. I have not myself had an opportunity of making any experiments at sea, but some have recently been made by Dr. Fischer, a surgeon in the German navy. From his experiments it would appear that the maximum distance to which, under ordinary circumstances, micro-organisms can be transported across the sea lies between 70 and 120 sea miles, and that beyond this distance they are almost invariably absent. A point of particular interest in connection with Dr. Fischer's experiments is that they show in a very striking manner that the microbes, which are always abundantly present in ordinary sea water, are not communicated to the air, excepting in the closest proximity to the surface, even when the ocean is much disturbed.

Before passing on to the microbial condition of the air within doors, I will just briefly refer to some experiments which I made at different altitudes, fully confirming those of Pasteur to which reference has already been made. Two gallons of air examined on the top and at the bottom of Primrose Hill, gave respectively nine and twenty-four micro-organisms. Again, the same volume of air examined at Norwich Cathedral on the top of the spire (300 feet) gave seven, on the tower (180 feet) nine, whilst on the ground eighteen were found.

Again, at St. Paul's Cathedral, the Golden Gallery yielded eleven, the Stone Gallery thirty-four, whilst the churchyard gave seventy.

Within doors we find that the number of micro-organisms suspended in the air depends, as we should have expected, upon the number of people present, and the amount of disturbance of the air which is taking place. In illustration of this the following experiments made at one of the Royal Society's conversaziones held at Burlington House last year may be mentioned. At the commencement of the evening, when a number of persons were already present, and the temperature was at 67° Fahr., the two gallons of air examined yielded 326 organisms; later on, as the rooms became densely crowded, as indicated by the temperature rising to 72° Fahr., the number reached 432. The next morning, on the other hand, when the room was empty, the air yielded only 130, but even this is doubtless in excess of the number which would be present in the room in question under normal conditions, in which, judging from experience, I should expect to find about 40 to 60 in the same volume of air. Again, I found that the air in the large entrance hall of the Natural History Museum in Cromwell Road yielded under ordinary conditions from 50 to 70 organisms in the same volume, but on Whit Monday, when an immense number of visitors were present in the building, I found as many as 280. Again, on a paying day at the South Kensington Museum, I found about 18, but on the Saturday, when no entrance fee is charged, there were as many as 73 organisms present in the same volume.

As an instance of the immense number of microbes which may under given circumstances be found suspended in the atmosphere, the following experiments, showing *the number falling on one square foot in one minute*, may be mentioned. The first experiment was made in a railway carriage (third class) on a journey from Norwich to London. Soon after leaving Norwich I tested the air; there were at the time four persons in the carriage, one window was closed, the other open, and the experiment was made near the open window. I found that under these conditions 395 organisms were falling on the square foot in one minute. On reaching Cambridge, the carriage was taken possession of by a number of men returning from Newmarket races, and remained quite full (ten persons) to

London. About halfway between Cambridge and London I made a second experiment, one window being shut, and the other was only open four inches at the top; the air was tested near the closed window, with the result that no less than 3,120 organisms were found to be falling on the square foot in one minute. On another occasion I made an experiment in a barn in which flail-threshing was going on. The atmosphere was visibly laden with dust, and on testing it I found that upwards of 8,000 organisms were falling on the square foot in one minute. It would probably be difficult to find a place in which the number of suspended microbes was greater than this, the great abundance of bacterial life in the material under treatment, the dryness of the latter, and the violent commotion occasioned by the threshing being all highly conducive to the distribution of an enormous multitude of micro-organisms throughout the air.

The careful study of the various micro-organisms present in air has hitherto received but little attention; it is, however, well known that important functions are performed by them in the laboratory of nature, but only in very few cases has any particular action been identified with a specific micro-organism. Apart from the theoretical interest attaching to the particular work performed by specific micro-organisms, there is the question of the influence which is exerted by these micro-organisms on health. Now, although there have been so far practically no organisms discovered in air which are known to be connected with any of the diseases to which man is subject, yet there cannot be a doubt that, in the immediate vicinity of the foci of infection, such harmful organisms are present, and that their distribution and conveyance through the atmosphere must take place in just the same manner as in the case of those micro-organisms which we have been considering. It is, moreover, this familiarity with the circumstances which are favourable or unfavourable to the dissemination of micro-organisms in general which should guide us in avoiding distributive influences coming into play in cases of zymotic disease and in the management of the sick-room generally. Thus it was from considerations of this kind that the principles of antiseptic surgery were laid down by Sir Joseph Lister. The manner in which the presence of micro-organisms in air should be regarded has been recently most concisely described by Professor Burdon Sanderson in the following words:—

> Considering that we know the living dust of the air *does* contain organisms which are capable of producing putrefaction and inflammation in wounds—for that is a thing about which we are certain—and that it *may* contain the distinctive or specific poisons of particular diseases; therefore, just as when rabies is prevalent amongst dogs all dogs should be taken care of, or as in countries where there are poisonous snakes care is taken to keep all snakes out of houses, so it behoves every one to be as careful as possible to maintain the air as free as possible from these

minute organisms, not because they are all dangerous, but because we do not know where the danger lurks. And hence the importance of acquiring a complete scientific knowledge of everything relating to their natural history, for it is only by the possession of this scientific knowledge that we can hope to become masters of the conditions which influence the development and growth, the origin and existence in the air and water and other media, of these more dangerous organisms on which disease is directly dependent.

PERCY FARADAY FRANKLAND.

NORTH BORNEO.

At 10 P.M. on the 3rd of April, 1887, the 'Sunbeam' anchored close under the lighthouse marking the entrance to the Sarawak river. The light stands on the high bluff of Tanjong Po. The first rays of the morning sun were shining on the rocky cliffs and wooded slopes of that noble eminence as we weighed anchor, and proceeded under steam, steering for the entrance to the Sarawak river. The distance from the sea to Kuching, the capital of Sarawak, is twenty-five miles. The river follows a most sinuous course, and the navigation is obstructed by many sunken dangers. There is no service of pilots. An excellent substitute is provided in the novel form of finger-posts, with directions in English warning the seaman of his approach to a rock or shoal, and directing him how to steer. The expedient is equally simple and effective. With close attention to the chart we made our way to Kuching, and anchored off the town at a point where the breadth of the river was barely sufficient for the 'Sunbeam' to swing round the anchor, after letting go on the flood tide.

We were in advance of the date originally projected for our arrival, and Rajah Brooke, the friend whom we had come from far to visit, was absent. The heat was such that it would have been impossible for the 'Sunbeam' to remain in the river. We determined to follow the Rajah to Labuan without delay. The 'Sunbeam' was despatched ten miles down the river to the Quop anchorage, and we committed ourselves for the day to the kind care of Mr. Maxwell, the resident at Kuching.

The town under his charge does infinite credit to its government. The population, consisting of the conflicting elements of Malays, Dyaks, and Chinese, is in perfect order. The public buildings include an excellent Court House, with various public offices, a prison, and barracks for the Sarawak Rangers, a small infantry force maintained for police purposes. There is a good church, in which the services of the Church of England are conducted by the Bishop. His see includes the Straits Settlements and the whole of North Borneo. A public library, a club, a capital hotel, a clean and spacious market, and a well-managed hospital, complete the list of public institutions.